Vegetation effects on airborne passive microwave response to soil moisture: A case study for the Rur catchment, Germany

Sayeh Hasan[(1)], Carsten Montzka[(1)], Heye Bogena[(1)], Chris Rüdiger[(2)], Muhammad Ali[(1)] and Harry Vereecken[(1)]

(1) Research Centre Jülich, Institute of Bio- and Geosciences: Agrosphere (IBG 3), Jülich, Germany

(2) Monash University, Department of Civil Engineering, Australia

• Introduction

For the soil moisture retrieval from passive microwave sensors such as the ESA Soil Moisture and Ocean Salinity (SMOS) and the NASA Soil Moisture Active and Passive (SMAP) mission, a good knowledge about the vegetation characteristics is necessary. Vegetation cover is one important factor in attenuating the soil signal and have a direct impact on the brightness temperature by direct canopy emission to the sensor or scattering and absorbing the soil emission. In the TERENO (Terrestrial Environmental Observatories) Rur site, Germany, radiation emitted from Earth's surface has been captured by Polarimetric L-band Multibeam Radiometer 2 (PLMR2) in order to map the brightness temperature and soil moisture at different altitudes to achieve a range of resolutions.

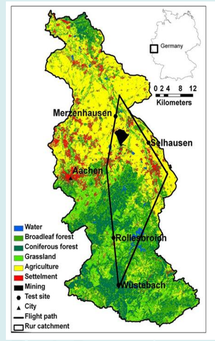

Fig 1. Rur catchment

• Materials and Methods

Tb records

- Warm and cold load calibration
- Georefrencing
- Filtering(roll>2.5°)
- Temperature correction

Fig 2. Polarimetric L-band Multibeam Radiometer 2

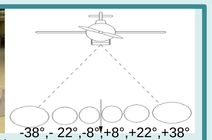

Fig 3. Six footprints of PLMR2

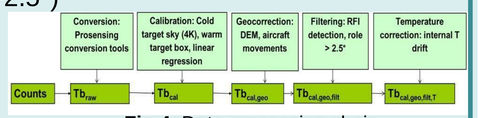

Fig 4. Data processing chain

L-MEB model

L-band microwave emission of the biosphere (L-MEB) model has been specifically developed to relate the observed brightness temperatures to surface soil moisture and simulate the L-band microwave emission over land surfaces.

$$Tb(\theta,p) = (1-\omega_{\theta,p})(1-\gamma_{\theta,p})(1+\Gamma_{\theta,p}\gamma_{\theta,p})T_v + (1-\Gamma_{\theta,p})\gamma_{\theta,p}\,T_{eff}$$

T_v is the vegetation physical temperature and T_{eff} is the soil effective temperature. ω and γ are respectively the single scattering albedo and the transmissivity of the vegetation layer. For every footprint, a Monte Carlo simulation is started with several model runs initialized with different soil moisture and b‘ values. The likelihood of the measured and calculated Tb identifies the corresponding soil moisture and b‘ values.

LAI estimation

Fig 5. Multispectral RapidEye satellite

Fig 6. LAI Retreived from RapidEye

- Remote sensing based LAI, used in this study, was estimated from NDVI (Normalized Difference Vegetation Index) and Fraction of vegetation cover

$$NDVI = (NIR - Red) / (NIR + Red)$$

$$FVC = (NDVI - NDVIs)/(NDVIv - NDVIs)$$

$$[LAI = -\ln(1-FVC) / k(\theta)]$$

- Estimated LAI was used to compute vegetation optical depth namely τ.
- τ can be estimated as a linear function of LAI and the empirical parameter b’, which is mainly dependent on the sensor frequency, polarization, canopy type and structure.

$$\tau = b'_s * LAI + b''_s$$

• Results

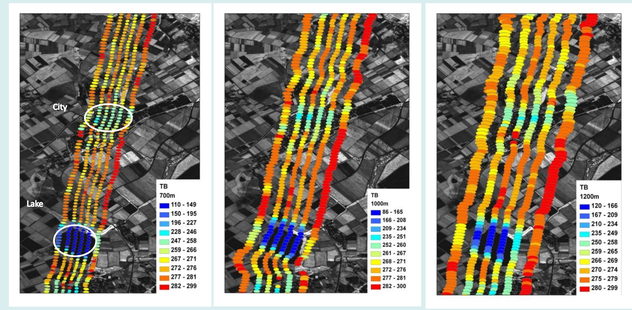

Fig 7. Brightness temperatures distribution at horizontal polarization for 3 different resolution observations. Flight altitude increases from left to right, 700m, 1000m and 1200m respectively.

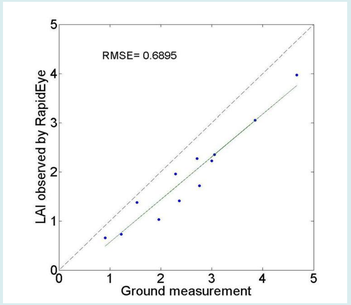

Fig 8. Observed LAI vs measured LAI at Selhausen test site

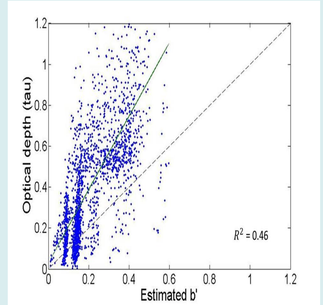

Fig 9. retrieved b’ parameter versus tau

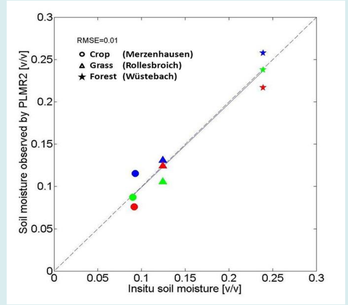

Fig10. Comparison of soil moisture retrieved by PLMR2 and ground measurement for different flight altitudes (700m-Blue, 1000m-Red and 1200m-Green)

Land cover	b‘	$\sigma(b')$	τ	$\sigma(\tau)$
Crop	0.14	0.06	0.22	0.1
Grass	0.08	0.03	0.19	0.08
Forest	0.27	0.1	0.57	0.2

Table 1. Mean b‘ and τ value and their standard deviation for the whole data set

• Conclusion

- Estimation of Vegetation optical depth (τ) from RapidEye data result an adequate accuracy.
- Root Mean Square Error (RMSE) of 0.01 m3m-3 over the region was achieved, which satisfies the SMAP target accuracy.

Reference

J. P. Wigneron, et al."L-band Microwave Emission of the Biosphere (L-MEB) Model: Description and calibration against experimental data sets over crop fields," *Remote Sensing of Environment,* vol. 107, pp. 639-655, 2007.

Acknowledgement

This study is funded by SFB/TR 32 “Pattern in Soil-Vegetation-Atmosphere Systems: Monitoring, Modelling, and Data Assimilation” which is gratefully acknowledged. We also thank Airborne Research Australia (ARA)